Report on the Study of Uniform End-Use Value Tests

DEPARTMENT OF AGRICULTURE
OFFICE OF THE SECRETARY
WASHINGTON, D. C. 20250

June 21, 1988

Honorable Patrick Leahy
Chairman, Committee on Agriculture
Nutrition, and Forestry
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

It is a pleasure to submit the enclosed study of uniform end-use value tests for grain. This study was conducted by the Department of Agriculture's Federal Grain Inspection Service (FGIS) and Agricultural Research Service (ARS) as mandated by P.L. 99-641, the Grain Quality Improvement Act of 1986.

That law directed FGIS and ARS to survey domestic and foreign buyers of grain to identify the information about grain characteristics that would be most useful to such buyers. Also, the Food Security Act of 1985 (P.L. 99-198) required the Office of Technology Assessment (OTA) to study U.S. grain export quality standards and grain handling practices. Due to considerable overlap in the two studies, FGIS, ARS, and OTA collaborated on the survey to minimize duplication and avoid unnecessary costs.

In brief, 178 domestic and 89 foreign users of wheat, corn, or soybeans were surveyed to obtain information on the quality attributes they consider important. Interestingly, most foreign and domestic buyers indicated that they use the Official U.S. Standards for Grain and that they find the information provided by the standards important. However, with the exception of domestic soybean processors, most buyers also rely on quality criteria not included in the current standards for purchasing specifications.

We expect that this study and the one to be published by OTA in the near future will be valuable in future discussions of the competitiveness of U.S. grains and oilseeds. I hope you find this information of interest.

Sincerely,

Richard E. Lyng

Enclosure

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Honorable E (Kika) de la Garza
Chairman, Committee on Agriculture
House of Representatives
Washington, D.C. 20515

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STUDY OF UNIFORM END-USE VALUE TESTS

Submitted by

Federal Grain Inspection Service (FGIS)

and

Agricultural Research Service (ARS)
U.S. Department of Agriculture

to the

Committee on Agriculture, Nutrition, and Forestry
United States Senate

and

Committee on Agriculture
House of Representatives

June 1988

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EXECUTIVE SUMMARY

The Grain Quality Improvement Act of 1986 directed the Federal Grain Inspection Service and the Agricultural Research Service to study the need for and availability of uniform end-use value tests for grain. Additionally, the 1985 Farm Bill required the Office of Technology Assessment to study U.S. grain export quality standards and grain handling practices. These studies were prompted by growing public concern over grain quality and declining U.S. grain exports.

In response to these requirements, the Office of Technology Assessment, Agricultural Research Service, and the Federal Grain Inspection Service jointly developed questionnaires to collect information from domestic wheat, corn, and soybean industries and foreign wheat markets. Foreign market data for corn and soybeans were obtained through surveys conducted by other research groups. One hundred seventy-eight domestic and 89 foreign users of wheat, corn, or soybeans responded to the quality attribute surveys.

Survey results are categorized by kind of grain.

Wheat -

1. Most domestic wheat millers and foreign wheat buyers use the U.S. wheat standards and find official factor information important.

2. Both domestic and foreign wheat users (buyers and millers) use quality criteria not included in the standards to establish purchasing specifications.

3. New official tests wanted were falling number, hidden and dead insect infestation, and pesticide and herbicide residues.

Corn -

1. Both domestic and foreign corn millers and feed dealers use the U.S. corn standards and find official factor information important.

2. Both domestic and foreign millers and feed dealers use quality criteria not included in the standards to establish purchasing specifications.

3. New official tests wanted varied between domestic and foreign corn users.

   Domestic corn millers and feed dealers expressed interest in tests detecting the presence of hidden and dead insect infestation, molds, mycotoxins, and pesticide and herbicide residues.

   Foreign corn users expressed interest in tests for protein, carbohydrates, fiber, stress cracks, and oil.

Soybeans -

1. Nearly all domestic and foreign soybean processors use the U.S. soybean standards and find official factor information important.

2. Domestic soybean processors use only U.S. soybean standards to establish purchasing specifications. They do not use additional quality criteria in their purchasing specifications. Foreign soybean processors, however, do specify quality criteria not included in the standards in their purchasing specifications.

3. New official tests wanted by both domestic and foreign soybean processors were oil, protein, free fatty acid, and chlorophyll content. Foreign soybean processors also expressed interest in a test for peroxide value.

Current testing criteria under the Official U.S. Standards for Grain primarily address the impurities, physical imperfections, and wholesomeness of grain at the time of inspection. Factors, such as moisture content, test weight per bushel, damaged kernels, and foreign material, are used to describe grain quality. The testing methodology used to determine these quality factors are timely, repeatable, simple, and cost effective. As such, the tests are applicable throughout the grain market and provide information to distinguish and segregate quality from the very first stage of the marketing system to the final end user.

The survey results indicate a need to expand the current standards to (1) address additional wholesomeness criteria such as, pesticide residues and hidden insect infestation, and (2) address certain intrinsic attributes of grain such as, the affect of alpha-amylase on wheat, the oil and protein content of soybeans, the level of free fatty acid in soybeans, the green (chlorophyll) color in soybean oil, and the degree of oil oxidation or deterioration in soybean oil. The Federal Grain Inspection Service with the assistance of the Agricultural Research Service is working toward the development of testing methodologies for these and other quality factors. As new technologies or testing methods become available, they must provide useful information on a market-wide basis and be timely, simple, repeatable, and cost effective to allow application throughout the marketplace from producer to exporter and end user.

There are three avenues for introducing new testing criteria into the official inspection system. The quality criteria (1) may be established at maximum or minimum limits corresponding to specific grade designations, (2) may be reported on each official grade certificate without limits, or (3) may be transmitted as information to the end-user and determined only upon request. The first procedure affects the grade designation based on the results of the test. The second and third procedures inform the end-user of the specific quality attributes while not affecting the numerical grade designation.

A. INTRODUCTION

The Official U.S. Standards for Grain (7 CFR, Part 810) serve as a common language for distinguishing the physical and biological condition of grain. Since 1916, the standards have enabled both buyer and seller to compare grain quality using equivalent forms of measurement. The equipment and tests used for comparing grain quality have changed over the years but the standards continue to reflect the needs of as many factions of the grain industry as possible and rely on testing methodologies that are timely, simple, repeatable, and cost effective.

Standards exist for 11 grains and oilseeds: corn, wheat, soybeans, sorghum, barley, oats, rye, flaxseed, sunflower seed, triticale, and mixed grain. Grades, class, and grain condition are based on factors defined in the standards. Factors vary by grain and may include test weight per bushel and the percent by weight of damaged kernels, foreign material, broken kernels, and other attributes. These factors serve as the basis for describing grain quality and fall into three basic quality categories: (1) wholesomeness, (2) physical characteristic, and (3) intrinsic attribute.

The standards address grain wholesomeness through the Sample grade and Special grade designation. Grain with an unacceptable odor, or grain that is heating, or grain containing stones, animal filth, toxic substances, or some other inferior condition, is labeled Sample grade, the lowest quality designation. Special grade designations are used to supplement other grading factors and specifically identify inferior quality conditions such as insect infestation, ergot, and garlic, or special quality conditions such as bright oats or waxy corn.

The physical quality characteristics of grain serve as the basis for the numerical grades established under the standards. Minimum or maximum limits are established for each numerical grade on factors such as broken kernels, foreign material and damaged kernels. Other physical conditions, such as moisture and dockage are nongrade determining factors but are included in the standards and reported as information.

The standards address the intrinsic qualities of grain, such as protein and oil as official criteria. These quality attributes do not affect the official grade designation and are tested only upon request.

Although the standards are available for use by the general public, the official application of the standards occurs through a national inspection system comprised of Federal, State, and private laboratories and administered by the Federal Grain Inspection Service (FGIS). This national inspection system involves official inspection personnel applying the grain standards using uniform testing procedures and approved equipment, all monitored through an elaborate FGIS quality control program. Inspectors issue the grade results on an official inspection certificate.

In 1986, public concern over grain quality problems and a decline in U.S. grain exports prompted legislation designed to improve U.S. grain quality. This legislation, the Grain Quality Improvement Act of 1986 (P.L. 99-641), amended the U.S. Grain Standards Act and more precisely stated the objectives of the grain standards. Specifically, the law stated that the Official U.S. Standards for Grain shall:

1. Define uniform and acceptable descriptive terms to facilitate trade in grain,

2. Provide information to aid in determining grain storability,

3. Offer users of such standards the best possible information from which to determine end-product yield and quality of grain, and

4. Provide the framework necessary for markets to establish grain quality improvement incentives.

The Grain Quality Improvement Act also required FGIS and the Agricultural Research Service (ARS) to study the need for and availability of uniform end-use value tests for grain. Specifically, the Grain Quality Improvement Act stated:

> "Sec. 307. Study of Uniform End-Use Value Tests. (a) Study. - The Secretary of Agriculture shall direct the Federal Grain Inspection Service and the Agricultural Research Service to conduct a study of the need for and availability of uniform end-use value tests for grain. The study shall include the following:
>
> (1) A survey of domestic and foreign buyers of grain to identify the information about grain characteristics that would be most useful to such buyers. The survey shall take into account those factors that buyers specify in contracts, test for, measure, or would measure if tests were available, including --
>
> (A) the starch, oil and protein content, breakage susceptibility, and individual kernel moisture in corn;
>
> (B) the baking characteristics, protein content, gluten content and quality, and milling hardness of wheat; and
>
> (C) the protein, oil, and free-fatty-acid content of soybeans.
>
> (2) A review of the development and availability of tests for the characteristics identified in the survey conducted under paragraph (1), including an evaluation of the costs of providing such tests."

In addition, the 1985 Farm Bill (P.L. 99-198) required the Office of Technology Assessment to study U.S. grain export quality standards and grain handling practices.

To complete these projects in an efficient and productive manner, the Office of Technology Assessment, ARS, and FGIS jointly developed several questionnaires to survey the domestic wheat, corn, and soybean industries and the foreign

wheat market. Foreign market data for corn and soybeans were obtained through surveys conducted by other research groups. The questionnaires were designed to obtain information from various end-users on those attributes they considered important to the quality of their specific product, such as hard wheat flour or soybean meal. Table I summarizes the type and number of end users contacted and the number of responses received.

The survey was limited to wheat, corn, and soybeans, the top U.S. grains and oilseed produced and exported.

Table 1 - Industries Contacted and Number of Responses

Industry	Number of Firms Contacted	Number of Responses	Percent Responses
Domestic			
Wheat Millers	117	57	48.7
Corn Dry Millers	64	24	37.5
Corn Wet Millers	6	4	66.7
Feed Industry	190	83	43.7
Soybean Processors	19	10	52.6
Foreign			
Wheat Buyers	*	47	
Corn Dry Millers	*	5	
Corn Wet Millers	*	19	
Feed Industry	*	7	
Soybean Processors	*	11	

* The number of foreign firms contacted is unknown.

B. WHEAT SURVEY RESULTS

1. U.S. Wheat Standards. The Official U.S. Standards for Wheat (7 CFR, Part 810, Section 810.2201 et. seq.) divides wheat into seven classes: Hard Red Spring wheat, Hard Red Winter wheat, Soft Red Winter wheat, Durum wheat, White wheat, Unclassed wheat, and Mixed wheat. Each class is divided into five U.S numerical grades and U.S. Sample grade. Wheat class, which is the first determination made on wheat, has been used in the past as an indicator for end use. The national inspection system first determines the wheat class before proceeding to inspect the wheat for grade and other conditions and criteria. Test weight per bushel, damaged kernels, foreign material, shrunken and broken kernels, defects, and the percentage of wheat of other classes are criteria used as grade determining factors. Defects include damaged kernels (total), foreign material, and shrunken and broken kernels. The percent of moisture and dockage is reported on each grade certificate, however, neither moisture nor dockage affect the grade designation. Dockage is all matter other than wheat and underdeveloped, shriveled, and small pieces of wheat kernels that can be mechanically removed from wheat. Conversely, foreign material is all matter

other than wheat that remains in the samples after the removal of dockage and shrunken and broken kernels. Additional tests, such as protein content of wheat, are available as official criteria under the U.S. Grain Standards Act but they do not affect the grade designation and must be specifically requested.

Official U.S. Standards for Wheat

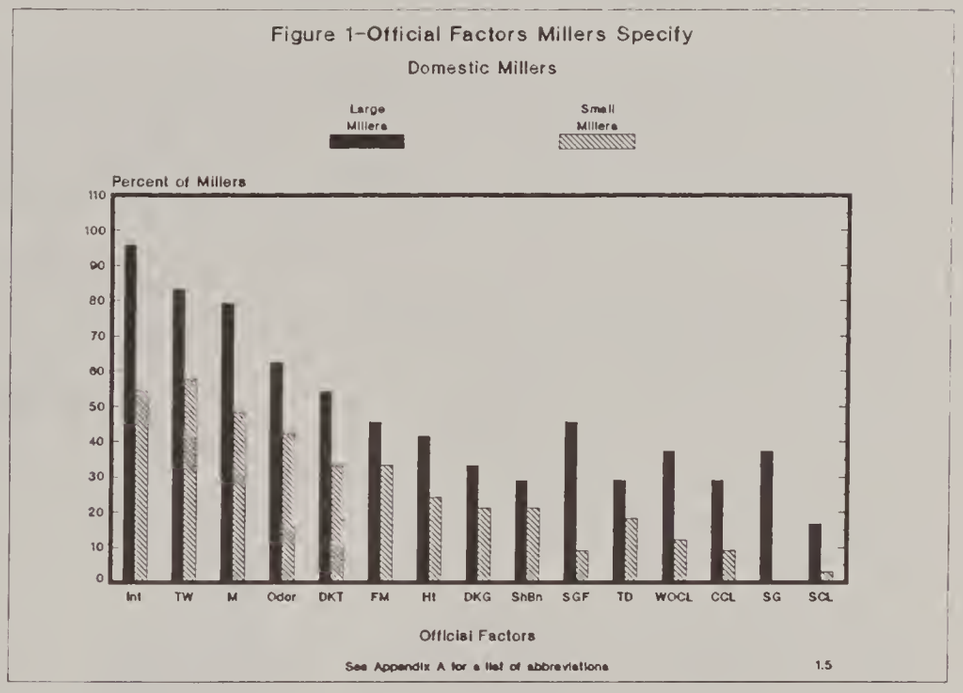
Grade	Minimum limits of--		Maximum limits of-							
	Test weight per bushel		Damaged Kernels						Wheat of other classes 4/	
	Hard Red Spring wheat or White Club wheat 1/	All other classes and subclasses	Heat damaged kernels	Total 2/	Foreign material	Shrunken and broken kernels	Defects 3/		Contrasting classes	Total 5/
	(pounds)	(pounds)	(percent)	(percent)	(percent)	(percent)	(percent)		(percent)	(percent)
U.S. No. 1	58.0	60.0	0.2	2.0	0.5	3.0	3.0		1.0	3.0
U.S. No. 2	57.0	58.0	0.2	4.0	1.0	5.0	5.0		2.0	5.0
U.S. No. 3	55.0	56.0	0.5	7.0	2.0	8.0	8.0		3.0	10.0
U.S. No. 4	53.0	54.0	1.0	10.0	3.0	12.0	12.0		10.0	10.0
U.S. No. 5	50.0	51.0	3.0	15.0	5.0	20.0	20.0		10.0	10.0
U.S. Sample grade:										
U.S. Sample grade is wheat that:										
(a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or										
(b) Contains 32 or more insect-damaged kernels per 100 grams of wheat; or										
(c) Contains 8 or more stones or any number of stones which have an aggregate weight in excess of 0.2 percent of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (Crotalaria spp.), 2 or more castor beans(Ricinus communis L.), 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 2 or more rodent pellets, bird droppings, or equivalent quantity of other animal filth per 1,000 grams of wheat; or										
(d) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or										
(e) Is heating or otherwise of distinctly low quality.										

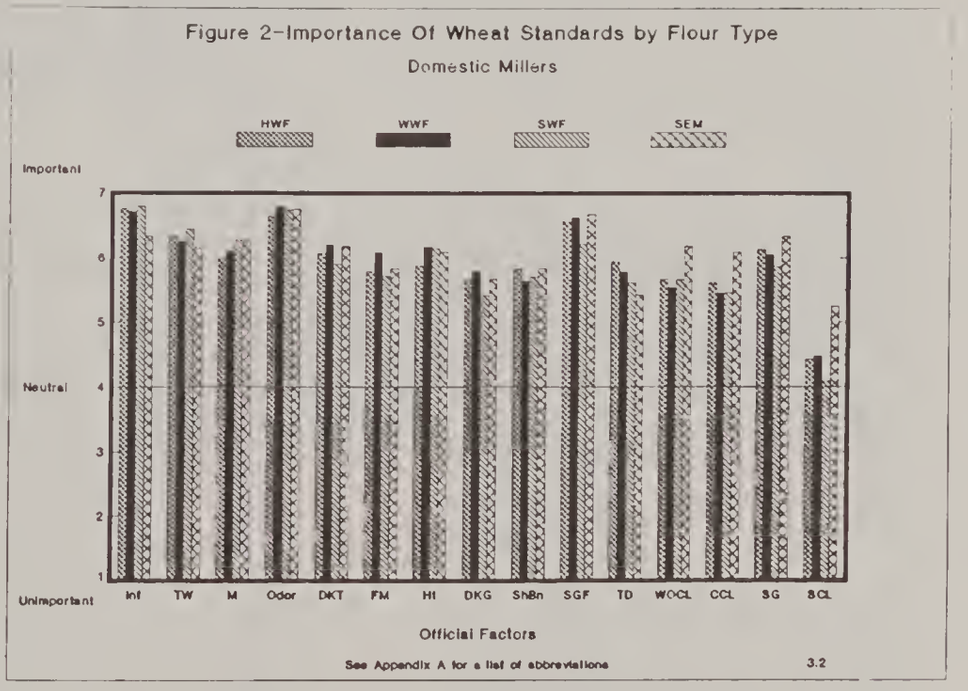
1/ These requirements also apply when Hard Red Spring or White Club wheat predominate in a sample of Mixed wheat.
2/ Includes heat-damaged kernels.
3/ Defects include damaged kernels (total), foreign material, and shrunken and broken kernels. The sum of these three factors may not exceed the limit for defects for each numerical grade.
4/ Unclassed wheat of any grade may contain not more than 10.0 percent of wheat of other classes.
5/ Includes contrasting classes.

2. Domestic Millers. Fifty-seven domestic U.S. wheat milling companies responded to the wheat quality attributes survey. They included 20 of the top milling companies representing approximately 83 percent of the U.S. daily milling capacity.

All of the 20 larger wheat milling firms and a major portion of the smaller mills use the Official U.S. Standards for Wheat as a basis for contract specifications. They may not receive official inspection services (just under 50 percent do), but they do use the U.S. wheat standards for describing wheat quality. However, half of the firms surveyed stated that the standards do not adequately reflect conditions important to their specific operations. Reasons why the standards are viewed incomplete or inadequate varied among mills. The lack of a test to detect hidden and dead insect infestation was most frequently (25 percent) cited as a weakness of the current wheat standards. When asked specific questions as to what end-use quality attributes are important and what additional testing or information are wanted, the responses reinforced the need to detect hidden and dead insect infestation and included several other quality factors.

Most milling firms using the standards do not solely rely on the grade designation to describe the quality of grain needed for their operations. They frequently set additional limits for certain factors as part of their purchasing requirements. Figure 1 shows which official factors under the U.S. wheat standards are used by domestic wheat millers (large vs. small) in addition to the grade for purchasing specifications and the frequency by which they are used. On the average, 79 percent of all the mills surveyed use the U.S. wheat standards. Of the 20 large U.S. milling companies, 100 percent use the standards. The six official factors used most frequently in purchasing specifications include: insect infestation, test weight per bushel, moisture, odor, damaged kernels (total), and foreign material. Based on a miller's specific needs, the acceptable limits for these factors may be modified in a contract from the official grade limits set in the U.S. wheat standards. For example, a mill may specify U.S. No. 2 wheat with sprout-damaged kernels (a type of damaged kernels) not to exceed 0.2 percent. The domestic wheat millers were also asked to rate the importance of all official factors using a scale of 1-7 by type of flour produced. The type of flour produced included hard wheat flour (HWF), whole wheat flour (WWF), soft wheat flour (SWF), and semolina (SEM). A rating of 1 represented an extremely unimportant factor while 7 represented an extremely important factor.





As shown in figure 2, the domestic wheat millers on the average rated all official factors as important with no significant difference between factors except for subclass which averaged on the lower level of importance for hard wheat, whole wheat, and soft wheat flours. A rating of 4 is considered neither important nor unimportant.

Although 79 percent of the domestic wheat millers use the wheat standards to describe quality for purchasing specifications, the standards do not address all of the miller's needs. In addition to adjusting the factor limits in the standards to meet their specific needs, 70 percent of the millers (88 percent large, 58 percent small) routinely specify other quality criteria limits in their sales contracts or purchasing orders. The five quality criteria most frequently used for purchasing specifications are: protein, hidden/dead insect infestation, pesticide/herbicide residue, falling numbers, and variety.

All of the large U.S. flour milling companies (representing 83 percent of daily U.S. flour production) that specify additional quality criteria in their purchasing specifications also routinely test for such quality criteria as part of their quality control program. In contrast, only 18 percent of the smaller mills perform internal quality control checks on other quality criteria.

Forty-seven (82 percent) of all millers surveyed find the need to perform quality control tests for quality criteria on a routine basis. The quality tests performed most frequently included falling number, protein, hidden/dead insect infestation, and pesticide/herbicide residue. The bake test and farinograph test are used by 30-38 percent of the firms on a routine basis for quality control purposes but are only used to a limited degree for establishing purchasing requirements.

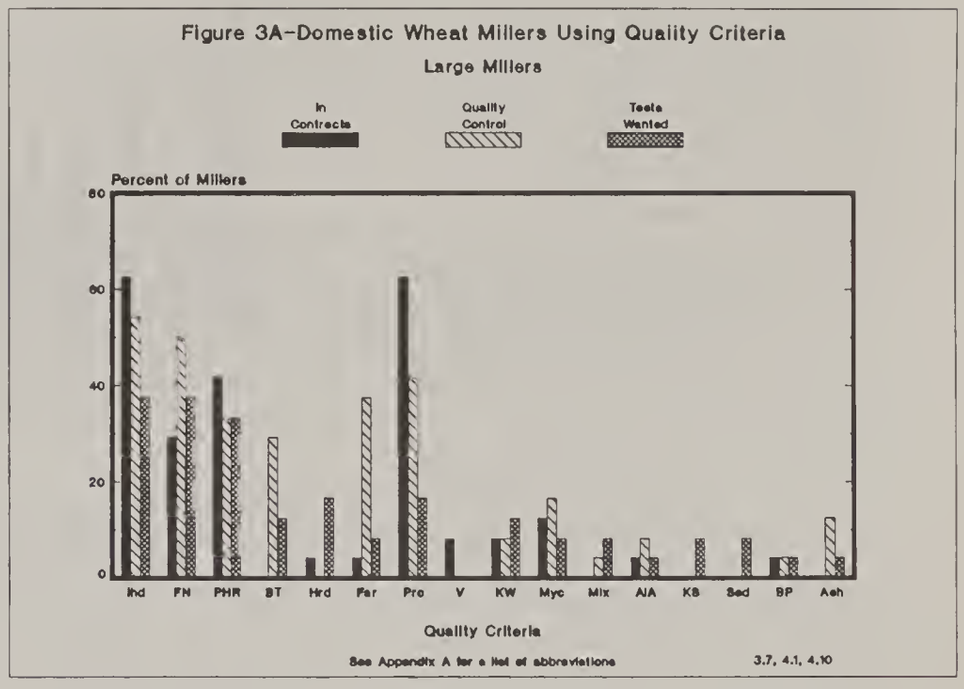


Figure 3A compares the percent of large millers using quality criteria for purchasing specifications (contracts) with the percent actually testing for these criteria (quality control) and the percent that would like additional tests (tests wanted).

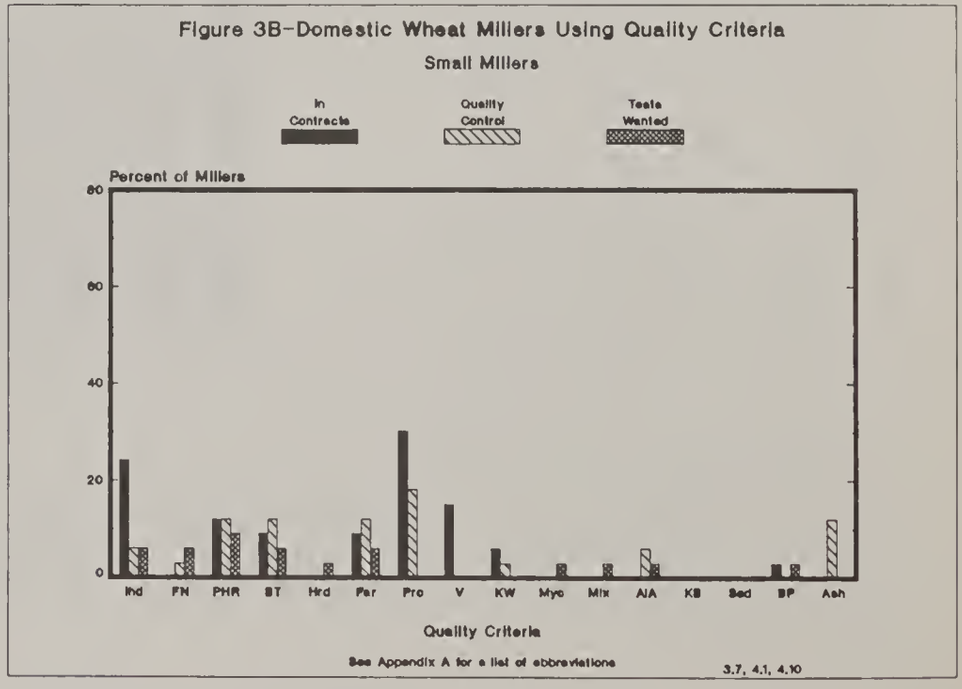


Figure 3B compares the percent of small millers using quality criteria for purchasing specifications (contracts) with the percent actually testing for these criteria (quality control) and the percent that would like additional tests (tests wanted).

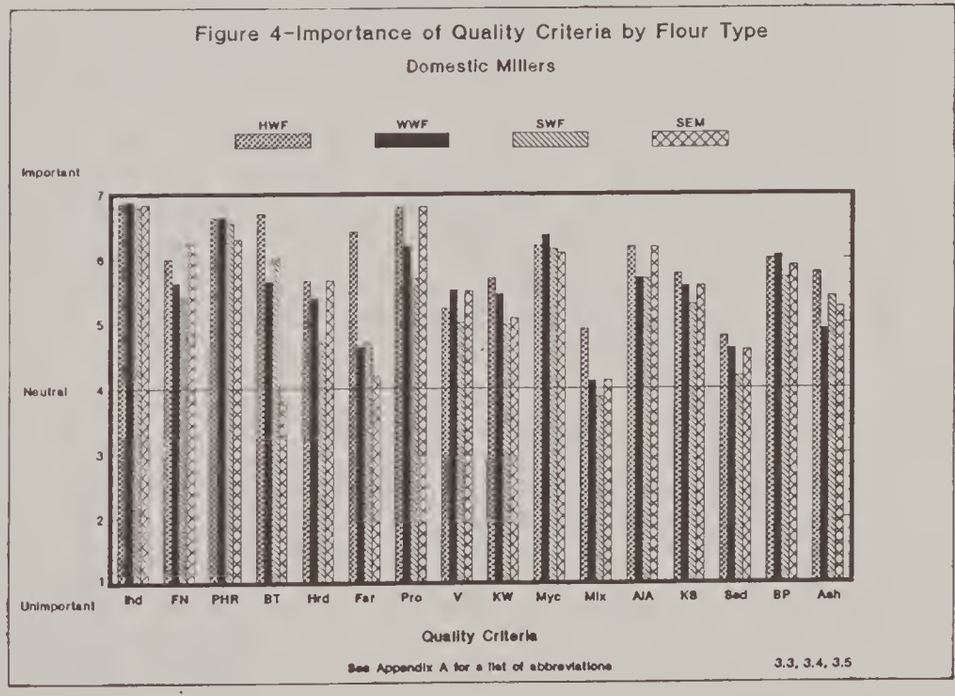
Both large and small milling firms use the top five quality criteria for specifying purchase requirements. The small mills use specific variety identification more frequently, and the large mills include criteria not addressed by smaller mills, such as falling number, mycotoxins, hardness, and alpha-amylase. Although protein and falling number are identified as tests wanted, official protein testing service and falling number service are available. These results, however, do not affect the grade designation.

After identifying which quality factors were used by millers to set purchasing specifications and which were actually tested for in the mills' quality control laboratories, the millers were asked to specify additional tests they would like included as official tests (figures 3A and 3B). All of the larger mills and 18.2 percent of the smaller milling firms specifying other quality criteria limits in contracts responded that additional tests are needed. Of all the millers responding that additional tests are needed, the most significant tests identified by the millers were hidden/dead insect infestation, falling number, and pesticide/herbicide residue. In addition to these three, the millers also identified the bake test, hardness, protein, and farinograph as other tests wanted.

As shown in figure 4, the millers were asked to rate the importance of various quality criteria. The top three quality factors used for purchasing (protein, hidden/dead insect infestation, and pesticide residue) and the top three tests wanted (hidden insect infestation, falling number, and pesticide residue) are among the highest rated quality criteria for all types of flour produced. The importance of the bake test and farinograph, two major tests performed by mill quality control laboratories, differs between flour types.

While the farinograph is considered very important for hard wheat flours, it has only a slight importance for the other flour types. Likewise, the bake test is important for hard wheat, whole wheat, and soft wheat flours but is less important for semolina.

Figure 4-Importance of Quality Criteria by Flour Type



In summary, the domestic wheat millers (1) use the current U.S. wheat standards and find the official factors important, (2) use various additional quality criteria to purchase wheat needed to meet their specific needs, and (3) most frequently identify hidden/dead insect infestation, falling number, and pesticide/herbicide residue as additional tests wanted.

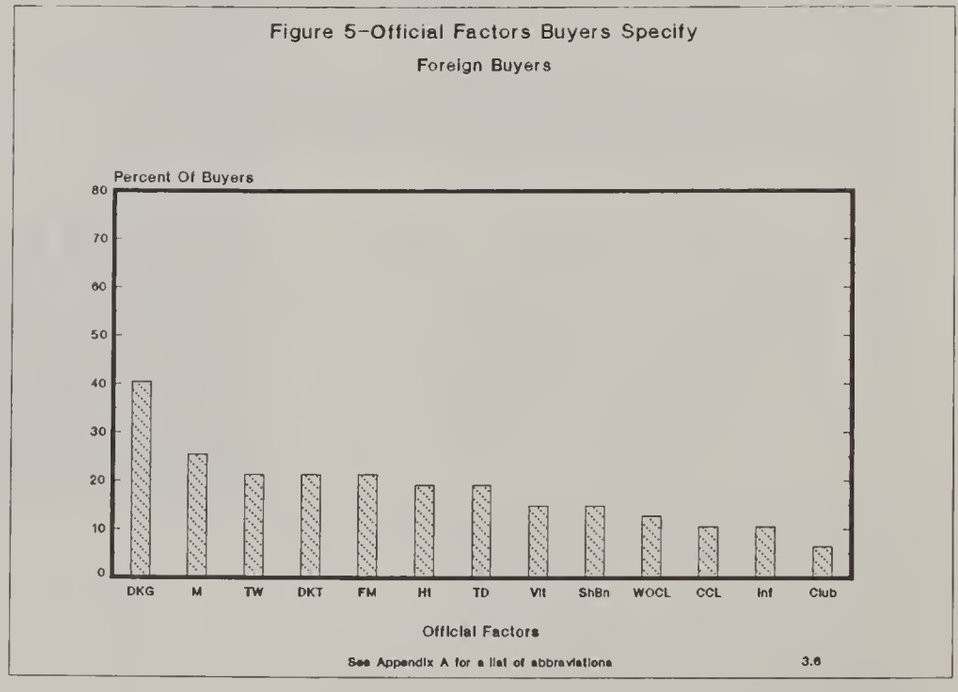
3. Foreign Buyers. A total of 47 foreign responses were received to the wheat quality attributes survey. These responses represented 29 actual milling firms, 8 government purchasing agencies, and 10 other private or semi-private purchasing organizations or firms.

Of the 47 responses, 16 firms or 34 percent stated that they use the U.S. wheat standards in their purchasing specifications. Nine of these 16 firms using the standards are non-mills, such as government purchasing agencies. Twenty-two of the 31 respondents that do not use the U.S. wheat standards for purchasing were actual flour millers. This relatively low number of foreign firms using the U.S. wheat standards reflects the current world marketing practice whereby a government agency or purchasing association buys U.S. grain using the wheat standards and then forwards the shipment through various channels to the final end user, such as a flour miller. Nearly all U.S. wheat exported is initially sold basis the Official U.S. Standards for Wheat. Figure 5 shows which official factors are used and the frequency of their use by the 16 foreign buyers that rely on the wheat standards for purchasing specifications.

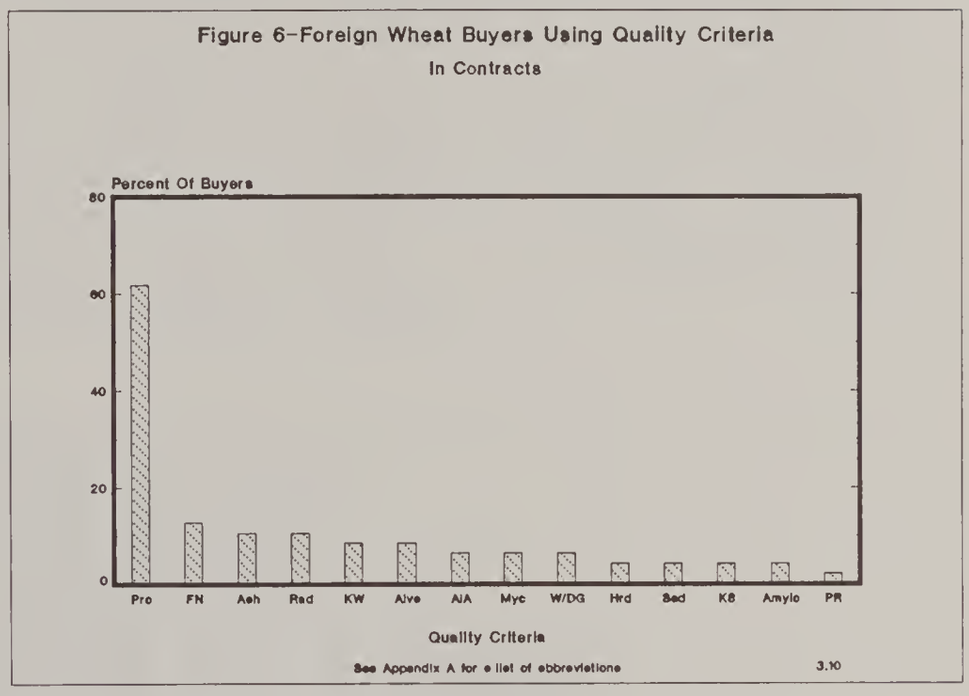
The five official factors used most frequently in purchasing specifications include: dockage, moisture, test weight per bushel, damaged kernels (total), and foreign material. Foreign buyers believe that each of these factors is important. The foreign and domestic wheat millers generally use the same official factors in their purchasing specifications. However, the domestic millers are more concerned with insect infestation than the foreign buyers. This can be attributed, in part, to the fact that only 63.8 percent of the foreign buyers indicated imported wheat is examined for live insect infestation upon arrival and even a lesser number (46.8 percent) are subject to government examinations of flour for the presence of insect fragments. In contrast, all domestic wheat millers are subject to the Food and Drug Administration insect fragment requirements.

Figure 5-Official Factors Buyers Specify

Foreign Buyers

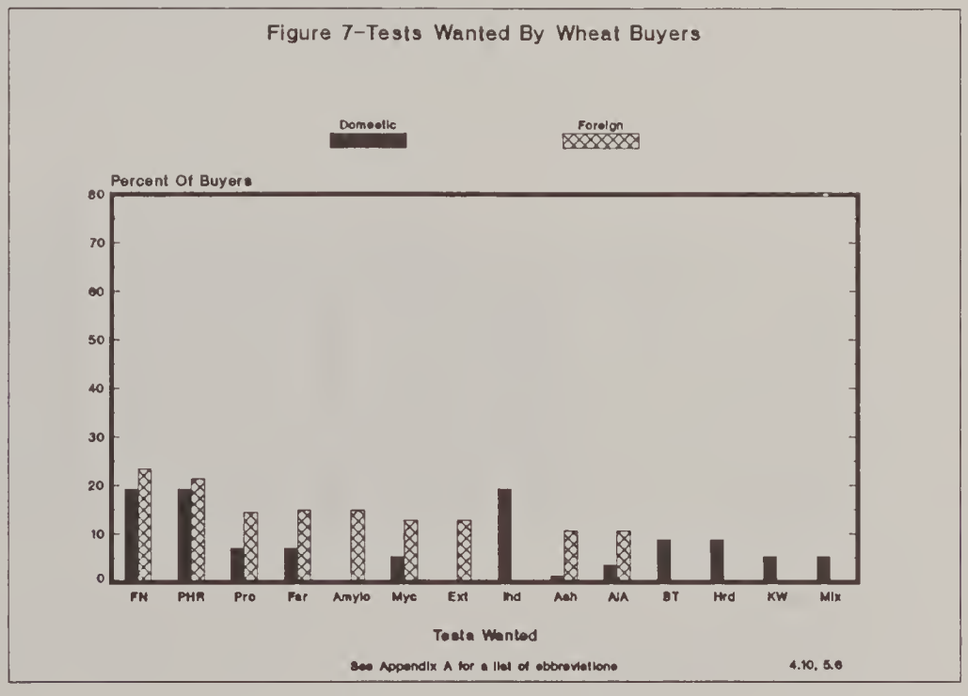


As with domestic millers, the foreign buyer finds that the U.S. wheat standards do not provide all the quality information needed for purchasing specifications. Foreign buyers include additional quality criteria in their contracts. Figure 6 shows the quality criteria specified in contracts.



A majority of the foreign buyers of U.S. wheat (78 percent) consider protein content an important factor. Consequently, over half (62 percent) of the foreign wheat millers include protein in their contracts. Other criteria included in purchasing specifications varied among buyers and were used less than 13 percent of the time. The most frequently used criteria, in addition to protein, were: falling number, ash, radiation, 1,000-kernel weight, and alveograph. Nearly half (47 percent) of the foreign wheat buyers believe that the U.S. wheat standards adequately reflect conditions important to their needs. This compares to only 28 percent of the domestic millers that believe the standards fulfill their needs. Of the foreign buyers that consider additional tests are needed, most want protein tests and falling number tests.

Fifty-seven percent of the foreign millers want additional tests. With the exception of a test for hidden/dead insect infestation which only the domestic millers identified as a need, the tests most frequently wanted (figure 7) by foreign and domestic millers were falling number and pesticide/herbicide residue. The foreign buyers may not have identified hidden/dead insect infestation as an important criteria because the survey questionnaire did not specifically list it as a criteria as was done for the domestic flour millers.



Foreign buyers are more interested in tests for protein, farinograph, amylograph, mycotoxins, extensigraph, ash, and alpha-amylase than domestic millers.

C. CORN SURVEY RESULTS

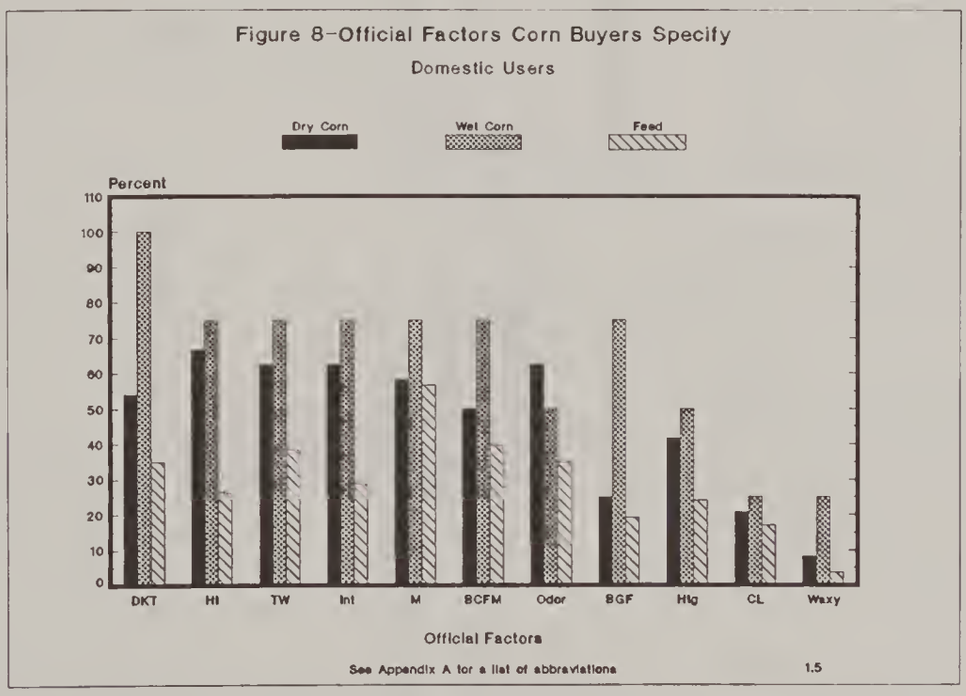
1. U.S. Corn Standards. The Official U.S. Standards for Corn (7 CFR, Part 810, Section 810.401 et seq.) divides corn into three classes: Yellow corn, White corn, and Mixed corn. Yellow corn is the class most often shipped for export from the United States. Each class of corn is divided into five U.S. numerical grades and U.S. Sample grade. The class designation classifies corn according to kernel color. Test weight per bushel, damaged kernels, and broken corn and foreign material are criteria used as grade determining factors. The percent of moisture is reported on each grade certificate, however, it does not affect the grade designation. Aflatoxin testing of corn is also available but is not part of the U.S. corn standards.

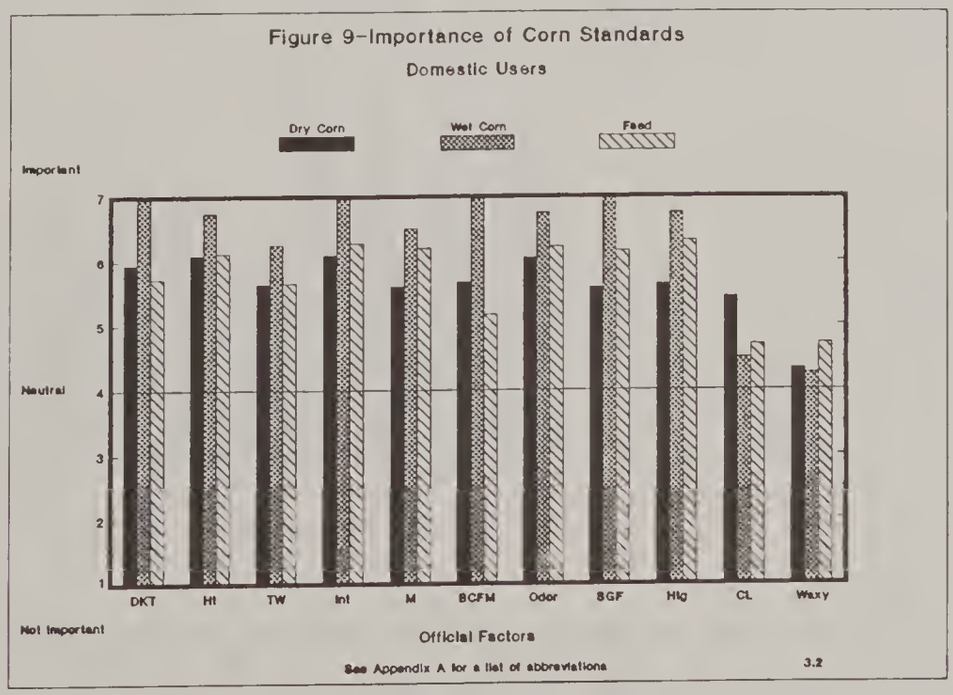
Official U.S. Standards for Corn

Grade	Minimum test weight per bushel	Maximum limits of --		
		Damaged Kernels		Broken corn and foreign material
		Heat-damaged kernels	Total	
	(pounds)	(percent)	(percent)	(percent)
U.S. No. 1	56.0	0.1	3.0	2.0
U.S. No. 2	54.0	0.2	5.0	3.0
U.S. No. 3	52.0	0.5	7.0	4.0
U.S. No. 4	49.0	1.0	10.0	5.0
U.S. No. 5	46.0	3.0	15.0	7.0
U.S. Sample grade:				
U.S. Sample grade is corn that:				
(a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or				
(b) Contains 8 or more stones which have an aggregate weight in excess of 0.20 percent of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (Crotalaria spp.), 2 or more castor beans (Ricinus communis L.), 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 8 or more cockleburs (Xanthium spp.) or similar seeds singly or in combination, or animal filth in excess of 0.20 percent in 1,000 grams; or				
(c) Has a musty, sour, or commercially objectionable foreign odor; or				
(d) Is heating or otherwise of distinctly low quality.				

2. Domestic Millers and Feed Dealers. Corn firms were divided into three groups: (1) dry corn millers, (2) wet corn millers, and (3) feed dealers. Table 1 on page 3 shows the number of firms contacted within each group. The response rate was very good, ranging from 38 percent to 76 percent. The vast majority of the firms responding to the survey use the U.S. corn standards as part of their purchasing specifications. All wet corn millers use the standards, and 75 percent of the dry corn millers and feed dealers use the standards for purchasing specifications. Corn users frequently establish specific limits for all official factors under the corn standards with the exception of class and the special "waxy" designation when making corn purchases. Class and "waxy" are generally specified in contracts as part of the numerical grade. Wet and dry corn millers include specific factors in their purchasing specifications more frequently than feed dealers (figure 8).

The corn firms were asked to rate the importance of all official factors under the U.S. corn standards using a scale of 1-7. A rating of 1 represented an extremely unimportant factor while 7 represented an extremely important factor. As shown in figure 9, the corn millers and feed dealers, on the average, rated all official factors important. Only minor differences are shown between types of users.





Corn millers and feed dealers also use quality factors not included in the corn standards for describing the quality of corn to be purchased. Thirty-six percent of the feed dealers and 71 percent of the dry and 75 percent of the wet corn millers include in their purchasing contracts other quality factors not included in the standards. The four tests most frequently included are: hidden/dead insect infestation, mold, pesticide/herbicide residue, and mycotoxins (figure 10). Other quality criteria used in contracts included: variety, stress cracks, artificial drying temperature, color, protein, breakage susceptibility, and age.

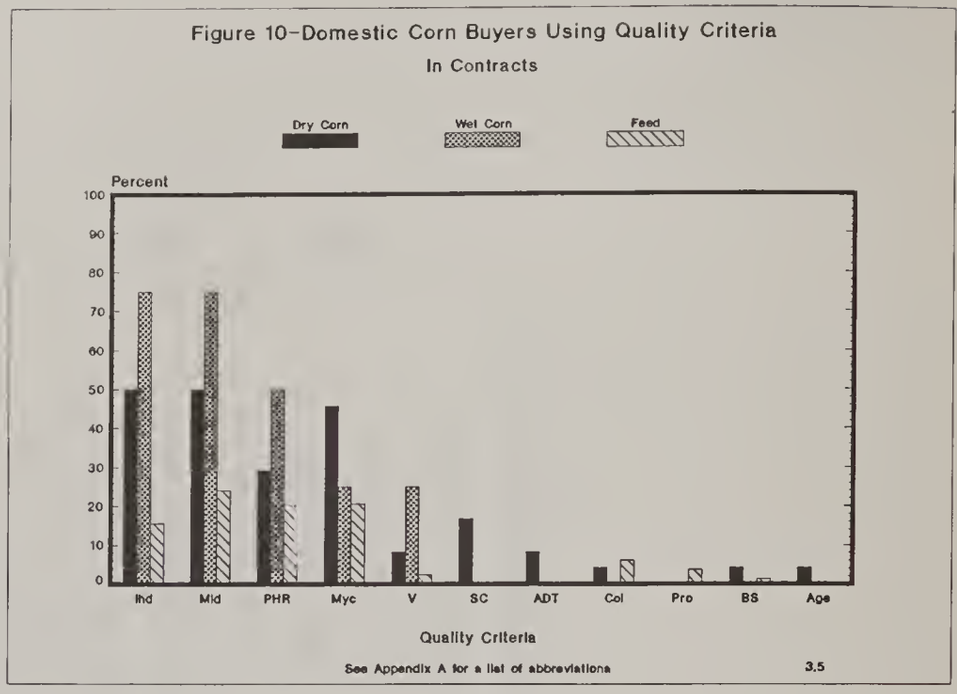
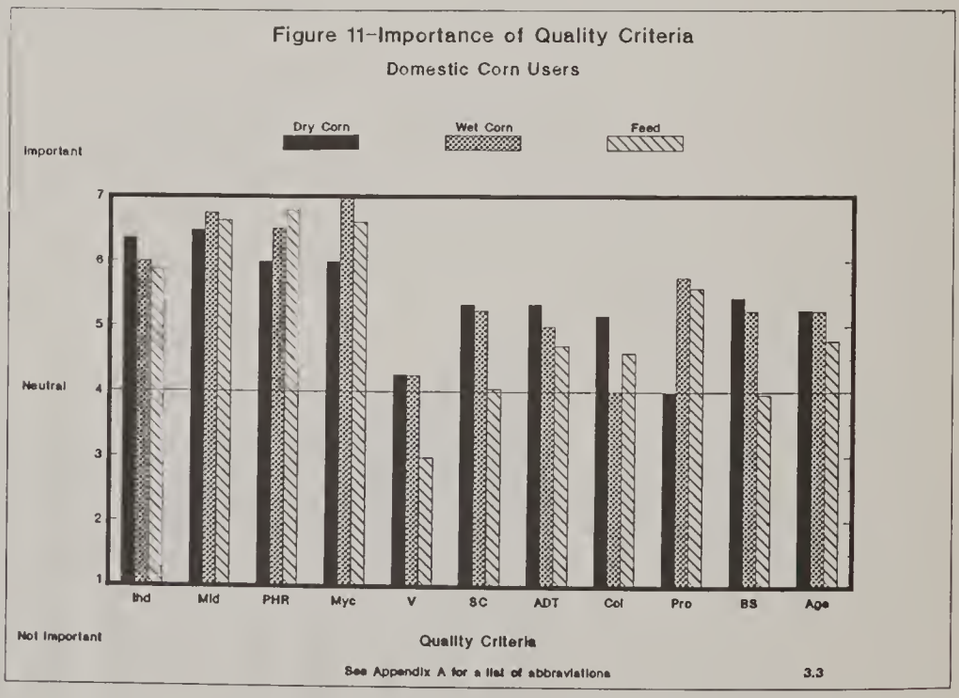


Figure 11 shows how the corn millers and feed dealers rate the importance of other quality criteria. The four criteria used most frequently in contracts (hidden/dead insect infestation, mold, mycotoxins, and pesticide/herbicide residue) are rated the highest in importance by each type of user. The majority of the remaining criteria were rated as slightly important or neutral.



Figures 12, 13, and 14 compare the percent of firms using quality criteria not included in the U.S. corn standards for purchasing specifications (contracts) with the percent of firms actually testing for these criteria (quality control) and the percent of firms that want additional tests (tests wanted). While between 71-75 percent of the corn dry and wet millers use quality criteria not included in the standards for purchasing specifications, only about half of the millers actively test corn receipts for such criteria using their quality control programs.

As shown in figures 12 and 13, the quality control testing performed by the dry and wet millers concentrates on the presence of molds and mycotoxins. The feed dealers that test corn receipts (28 percent) also focus on the presence of molds and mycotoxins as well as protein content (figure 14).

The vast majority (82 percent) of the corn firms don't want additional tests. None of the wet corn millers wanted any additional tests. About 38 percent of the dry corn millers and 13 percent of the feed dealers wanted additional tests. The most frequently wanted tests are for mold, mycotoxins, pesticide/herbicide residue, stress cracks, protein, and hidden/dead insect infestation. The types of tests most frequently wanted are the same as the types of tests most frequently included in purchasing specifications and quality control programs.

While over 60 percent of the wet corn millers and feed dealers believe that the standards adequately reflect conditions important to their operations, only 37 percent of the dry millers believe so. The most frequently cited reasons for dissatisfaction are lack of tests for mycotoxins, mold, pesticide/herbicide residue, and hidden/dead insect infestation.

Figure 12-Domestic Corn Buyers Using Quality Criteria

Dry Millers

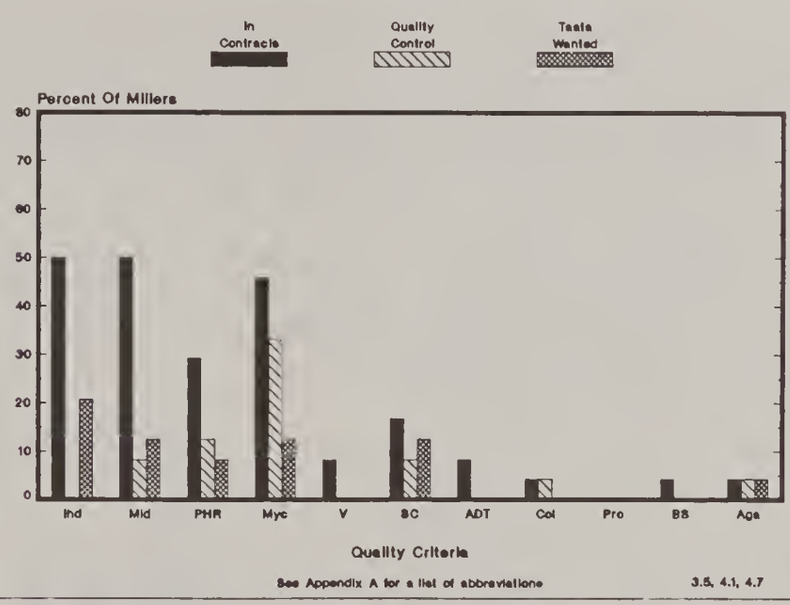


Figure 13-Domestic Corn Buyers Using Quality Criteria

Wet Millers

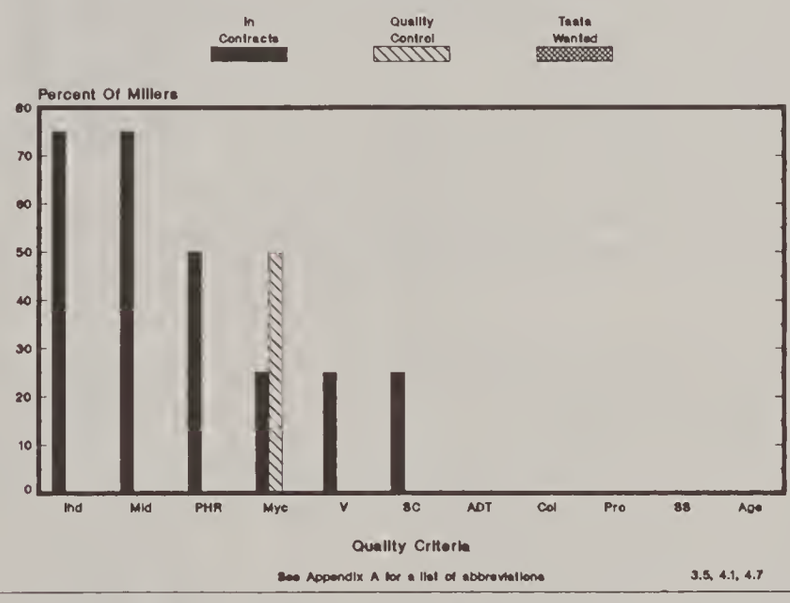
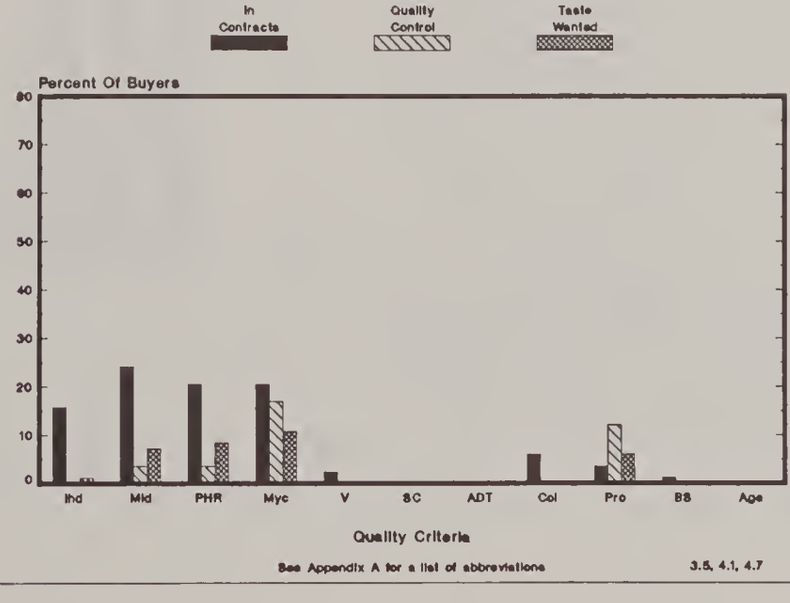


Figure 14-Domestic Corn Buyers Using Quality Criteria

Feed Dealers



3. Foreign Buyers. Thirty-one foreign corn firms responded to the survey. However, most of the foreign firms only answered a few of the survey questions. As a result, our information is limited to the questions concerning the factors they include in their contracts and the factors they test for in their quality control programs.

Figure 15 shows there is considerable similarity between the major factors wet millers and feed dealers include in their purchasing specifications. Both end users frequently use broken corn and foreign material, moisture, and damaged kernels (total) in their purchasing specifications. Three tests not included in the current U.S. corn standards (protein, fiber, and carbohydrates) are used by a large share (71, 57, and 43 percent, respectively) of the feed dealers in their purchasing specifications. Wet and dry corn millers do not use these criteria to any appreciable amount.

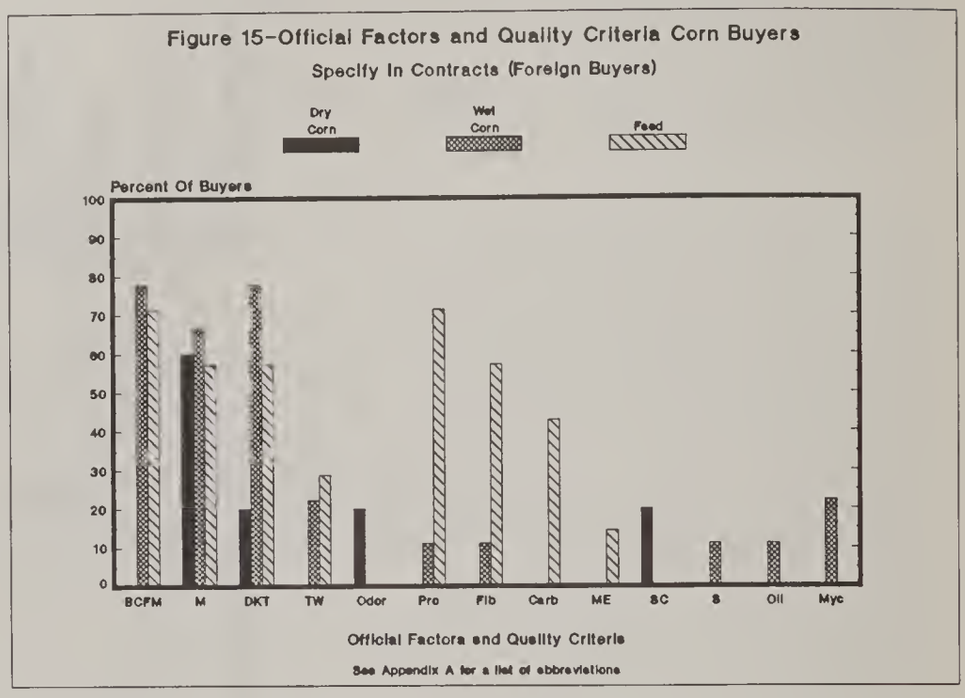
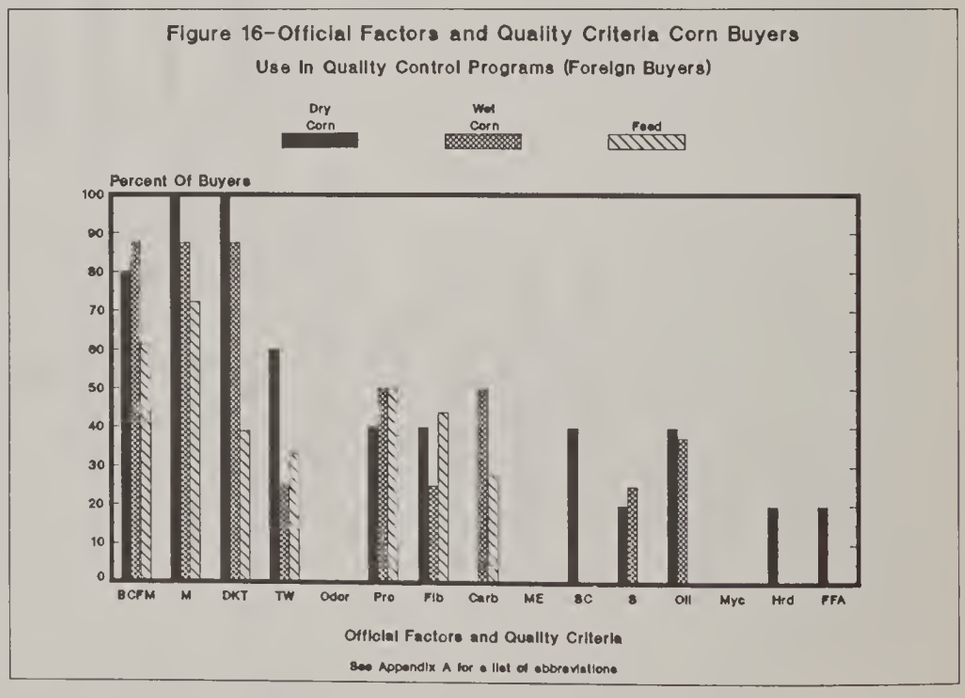


Figure 16 shows the quality control tests performed by foreign corn firms. Moisture, broken corn and foreign material, damaged kernels (total), and test weight per bushel are the official factors most frequently included in quality control programs. A large percentage (25-50 percent) of the firms also include tests for protein, carbohydrates, fiber, stress cracks, and oil in their quality control programs.



Comparing the domestic and foreign surveys reveals that domestic corn millers and feed dealers are interested in additional tests that address mold, mycotoxins, chemical residues, and protein; whereas, the foreign corn firms are more interested in tests that reflect protein, carbohydrates, fiber, stress cracks, and oil.

D. SOYBEAN SURVEY RESULTS

1. U.S. Soybean Standards. The Official U.S. Standards for Soybeans (7 CFR, Part 810, Section 810.1601 et seq.) divides soybeans into two classes: Yellow soybeans and Mixed soybeans. Yellow soybeans is the class shipped for export from the United States. Each class of soybeans is divided into four U.S. numerical grades and U.S. Sample grade. Test weight per bushel, damaged kernels, foreign material, split kernels, and soybeans of other colors are criteria used as grade determining factors. The percent of moisture is reported on each grade certificate, however, it does not affect the grade designation.

Official U.S. Standards for Soybeans

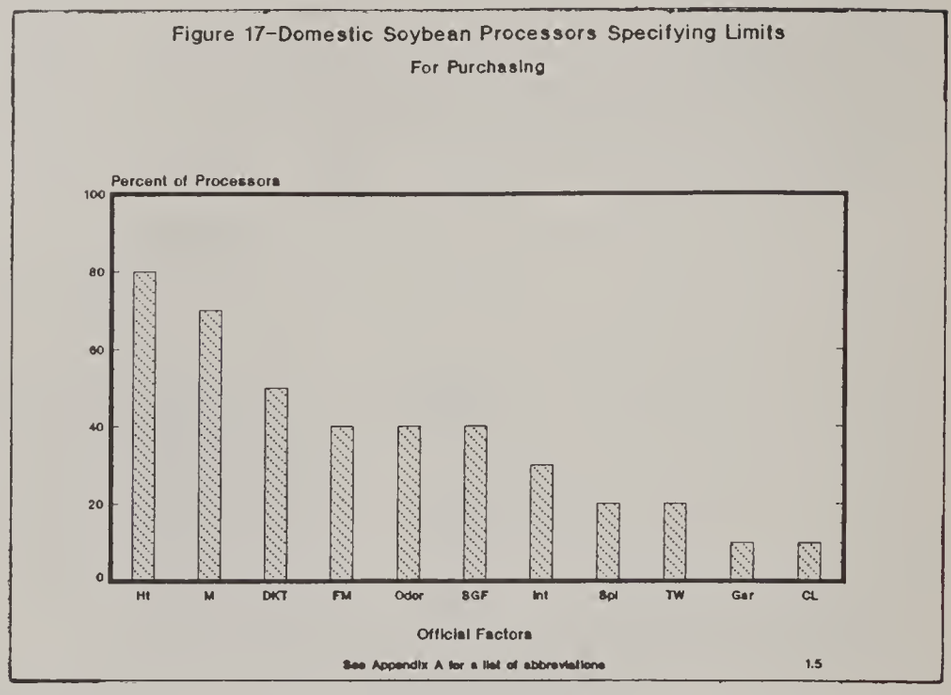
Grade	Minimum Test Weight Per Bushel	Maximum limits of--				
		Damaged Kernels		Foreign	Splits	Soybeans of other colors
		Heat damaged (percent)	Total (percent)	(percent)	(percent)	(percent)
U.S. No. 1	56.0	0.2	2.0	1.0	10.0	1.0
U.S. No. 2	54.0	0.5	3.0	2.0	20.0	2.0
U.S. No. 3 1/	52.0	1.0	5.0	3.0	30.0	5.0
U.S. No. 4 2/	49.0	3.0	8.0	5.0	40.0	10.0
U.S. Sample grade:						
U.S. Sample grade is soybeans that:						
(a) Do not meet the requirements for U.S. No. 1, 2, 3, 4; or						
(b) Contain 8 or more stones which have an aggregate weight in excess of 0.2 percent of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (Crotalaria spp.), 2 or more castor beans (Ricinus communis L.): 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s) 10 or more rodent pellets, bird droppings, or equivalent quantity of other animal filth per 1,000 grams of soybeans; or						
(c) Have a musty, sour, or commercially objectionable foreign odor (except garlic odor); or						
(d) Are heating or otherwise of distinctly low quality.						

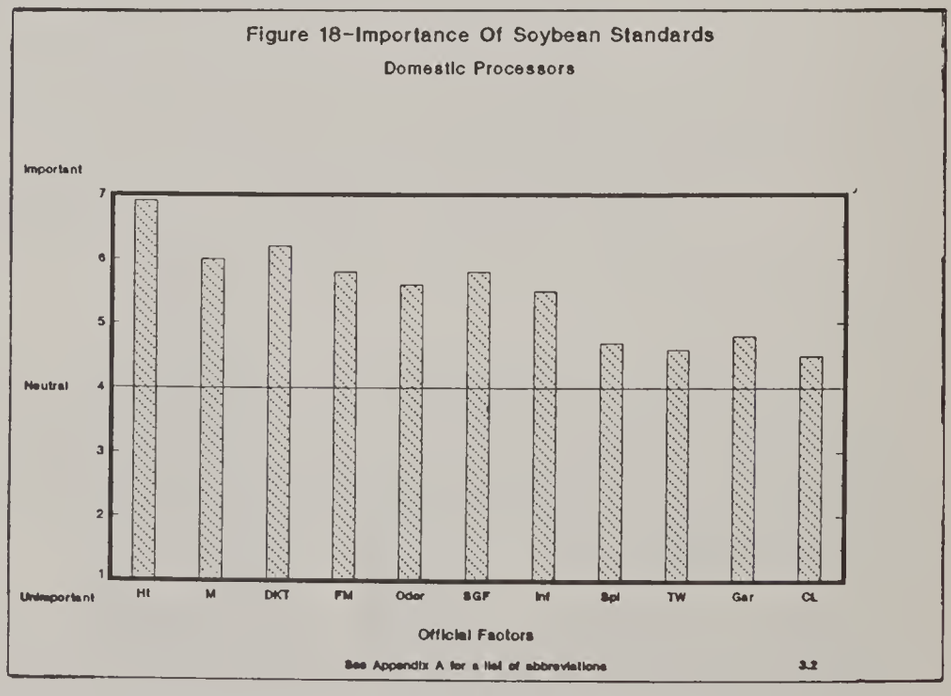
1/ Soybeans that are purple mottled or stained are graded not higher than U.S. No. 3.
2/ Soybeans that are materially weathered are graded not higher than U.S. No. 4.

2. Domestic Processors. Ten domestic U.S. soybean processing companies responded to the soybean quality attributes survey. All of the soybean processors responding to the survey use the Official U.S. Standards for Soybeans for describing soybean quality. Sixty percent of the soybean processors responding to the survey obtain official inspection services for inbound shipments.

One third of the firms surveyed stated that the standards do not adequately reflect conditions important to their specific operations. The lack of tests for protein and oil were cited as reasons why the standards are incomplete. When asked specific questions as to what quality attributes are important and what additional testing or information would be useful, the responses identified oil and protein as the most important.

Although all of the domestic soybean processors use the standards, they do not solely rely on the grade designation to describe the quality of grain needed for their operations. They frequently set additional limits for certain factors as part of their purchasing requirements. Figure 17 shows which official factor under the U.S. soybean standards are used by domestic soybean processors in addition to the grade for purchasing specifications and the frequency by which they are used. The six official factors used most frequently in purchasing specifications include: heat-damaged kernels, moisture, damaged kernels (total), foreign material, odor, and Sample grade factors. Based on a processor's specific needs, the acceptable limits for these factors may be modified in a contract from the official grade limits set in the U.S. soybean standards.





The domestic soybean processors were also asked to rate the importance of all official factors using a scale of 1-7. A rating of 1 represented an extremely unimportant factor while 7 represented an extremely important factor. A rating of 4 is considered neither important nor unimportant. Figure 18 shows the domestic soybean processors on the average rated all official factors as important with heat-damaged kernels being most important.

Although 100 percent of the domestic soybean processors surveyed use the soybean standards to describe quality for purchasing specifications, the standards do not address all of the processor's needs. Half of the responding processors routinely perform tests for other quality criteria; however, these quality criteria are not included in their sales contracts or purchasing orders. The quality criteria routinely tested by domestic processors include protein and oil. Other quality criteria considered by the domestic soybean processor include pesticide/herbicide residues, free fatty acid, hidden/dead

insect infestation, and chlorophyll content. These other quality criteria are not specified in sales contracts nor are they routinely tested as part of the processors quality control program. Figure 19 compares the percent of processors using quality criteria for purchasing specifications (contracts) with the percent of firms routinely testing for these criteria (quality control) and the percent of processors that would like additional tests (tests wanted).

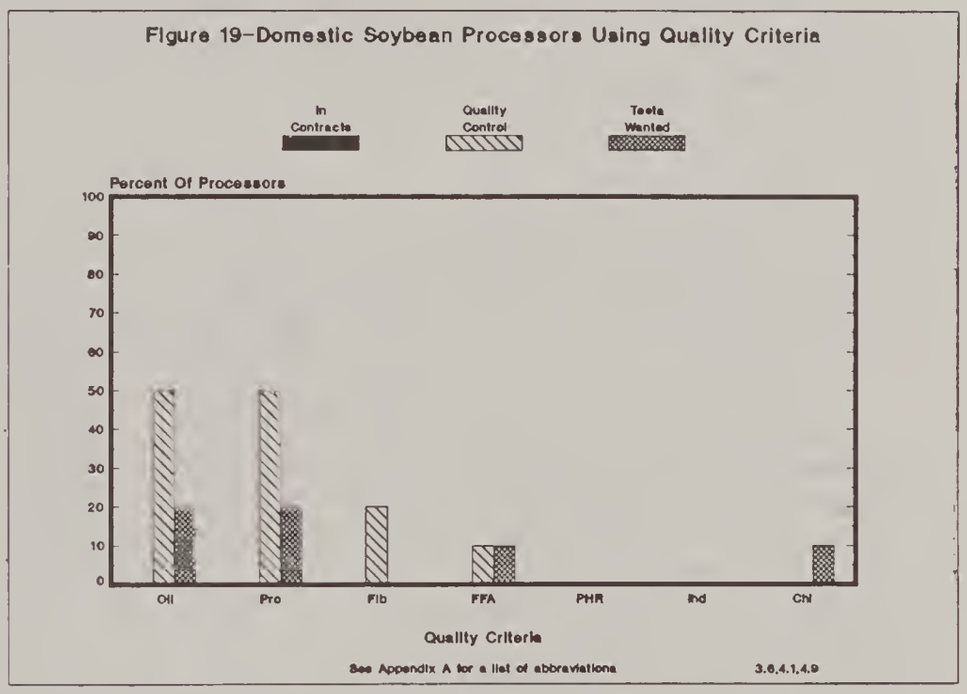


Figure 19–Domestic Soybean Processors Using Quality Criteria

After identifying which quality criteria were used by processors to set purchasing specifications, routinely tested by the processor, and additional tests wanted by processors, they were asked to rate the importance of the quality criteria not currently included in the standards. Figure 20 shows the domestic soybean processors on the average rated oil, protein, pesticide/herbicide residue, free fatty acid, chlorophyll content, and hidden/dead insect infestation as important criteria; but they only identified oil, protein, fiber, and free fatty acid as routinely tested for quality control purposes (figure 19). Domestic soybean processors did not rank the importance of fiber.

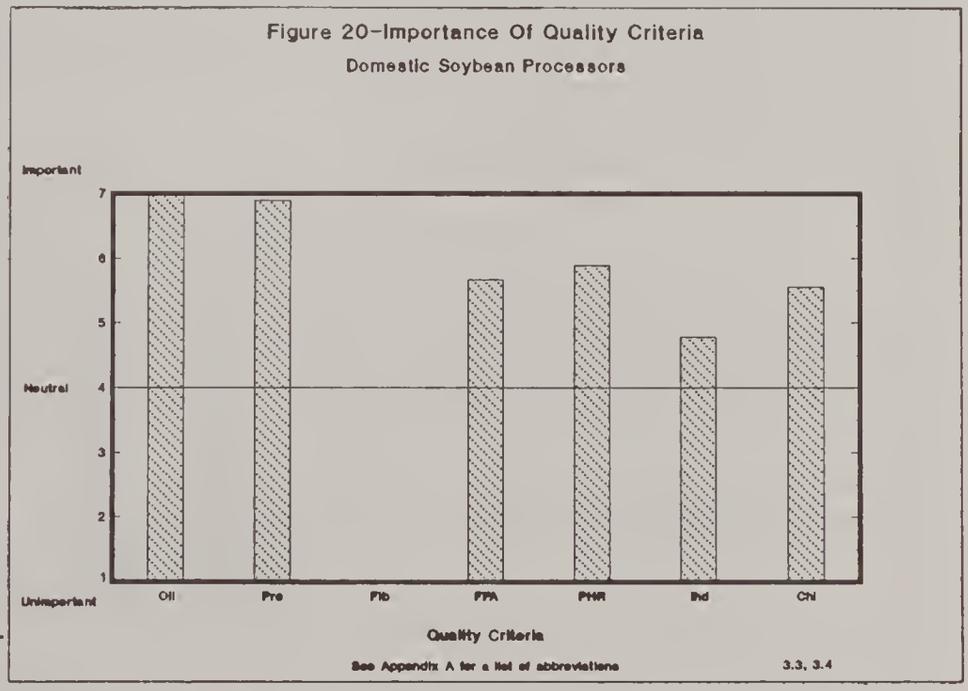


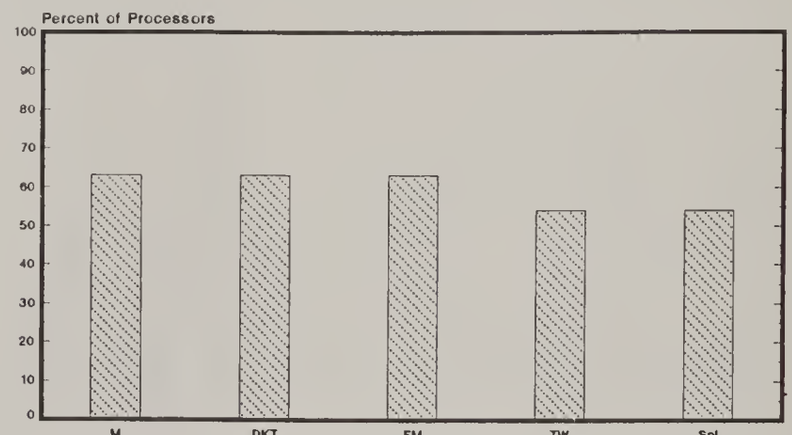
Figure 20–Importance Of Quality Criteria
Domestic Soybean Processors

In summary, domestic soybean processors (1) use the current U.S. soybean standards and find the official factors important, (2) do not use additional quality criteria to purchase soybeans, (3) identified oil and protein as quality criteria routinely tested as part of their quality control program and consider these criteria as most important to their operation, and (4) would like oil and protein testing services as additional tests. Free fatty acid and chlorophyll content determinations were also identified as additional tests processors want; however, these criteria are not specified in the sales contracts and are not major factors in their quality control program.

3. Foreign Processors. A total of 11 foreign responses were received to the soybean end-product quality survey. Of the 11 responses 10 foreign processors or 91 percent stated that they use the U.S. soybean standards for grade in their purchasing specifications. Figure 21 shows which official factors are used and the frequency of their use by the foreign processors.

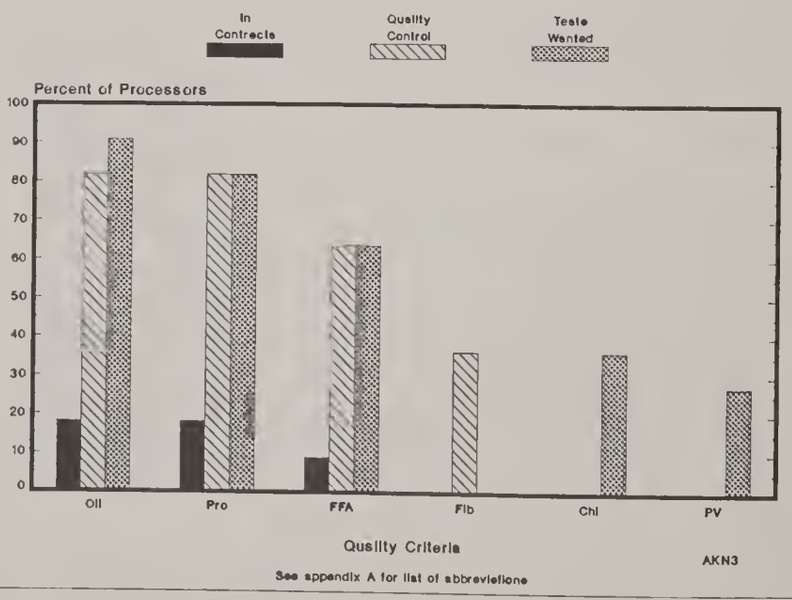
The five official factors used in purchasing specifications include: moisture, damaged kernels (total), foreign material, test weight per bushel, and splits. Foreign and domestic soybean processors generally use the same official factors in their purchasing specifications.

Figure 21-Foreign Soybean Processors Specifying Limits For Purchasing



In general, foreign processors find that the U.S. soybean standards do not provide all the quality information needed for purchasing specifications. Consequently, foreign processors include additional quality criteria in their sales contracts. Figure 22 identifies the different quality criteria specified in foreign sales contracts, quality criteria tested upon receipt of the shipment, and tests foreign processors want.

Figure-22 Foreign Soybean Processors Using Quality Criteria



Although only 2 of the 11 responding foreign processors include oil and protein specifications in their sales contracts, 9 out of the 11 processors do test for oil and protein upon delivery of each shipment. One out of the 11 responding foreign processors include free fatty acid specifications in their sales contracts, yet 7 out of the 11 processors test for free fatty acid upon delivery of each shipment. Four out of the 11 processors test for fiber upon delivery of each shipment; however, fiber is not included in their sales contracts. Although these four quality criteria are not always included in foreign sales contracts, foreign processors consider them important to their operations.

Ninety-one percent of the foreign processors indicated additional tests are wanted. Figure 22 shows the additional quality criteria foreign processors want. Like the domestic processors, foreign processors want tests for oil, protein, free fatty acid, and chlorophyll content. Foreign processors also want a test for peroxide value.

Although foreign processors would like tests for chlorophyll content and peroxide value, they did not indicate they include these specifications in their sales contracts. Additionally, they did not indicate they routinely test for these characteristics.

E. CURRENT TESTING CRITERIA

The testing criteria under the current Official U.S. Standards for Grain primarily address impurities, physical imperfections, and wholesomeness of the grain at the time of inspection. Factors, such as moisture content, test weight per bushel, damaged kernels, and foreign material, are typically used to describe the quality of the grain. The technological advances in the area of near-infrared reflectance (NIR) have opened new possibilities for providing end-use quality information in addition to the current criteria. Wheat protein testing is one example of how NIR technology permits the rapid, timely, and accurate analysis of grain for an end-use quality attribute.

For a testing methodology to meet the needs of the grain market, five basic criteria must be met:

1. Importance. First and foremost, the test must provide useful information on a market-wide basis. Expanding the standards to include information not widely used within the industry limits the value of the standards and may even be counterproductive by complicating the standards to the point that users revert to other means for describing grain quality.

2. Timely. A test must be performed in a reasonable period of time. Country elevators must be able to apply the standards to inbound grain during harvest which may mean testing a truck load of grain every 5 to 10 minutes. Likewise, official inspectors at export grain facilities are faced with analyzing a sample every 15-20 minutes as the facility loads at rates reaching 100,000 plus bushels per hour. If the marketplace uses a specific quality attribute to define grain value, then starting with the very first stage of the marketing system the ability must exist to distinguish quality and segregate accordingly.

3. Simple. A test must be simple enough to be performed throughout the marketing system from when the grain first arrives at the country elevator until it ends up at a domestic user or an export elevator. Complicated chemical testing procedures work well in many end-user quality control laboratories but are not adaptable to the work environment and informational needs of today's inspection system.

4. Repeatable. Test results must be repeatable if they are going to serve as a common language over periods of time and between geographical areas. An exporter buying grain from various regions of the United States to fulfill specific export quality requirements must be assured that any significant difference in quality between origin and destination is not due to testing variability.

5. Cost Effective. The cost of performing a test must be reasonable. As with the other four criteria, for the standards to serve as a common language, they must be applicable throughout the marketing system. Expensive tests would not be acceptable to the users of the standards.

F. AVAILABILITY OF NEW TESTS

The current testing criteria discussed in section E above will remain applicable in the future. Any test incorporated into the U.S. grain standards as official factor or official criteria must be important, timely, simple, repeatable, and inexpensive. Consequently, to provide the quality information identified as important in sections B through D of this report, FGIS must rely on technology. As previously stated, NIR technology is an excellent example of how needed quality information can be provided and meet the strict requirements of the grain inspection system. Table 2 summarizes the quality tests most frequently identified by domestic and foreign users as additional tests wanted.

Table 2 - Summary of Additional Tests Wanted 1/

Wheat	Corn	Soybeans
* Falling Number	* Hidden/Dead Insect Infestation	* Oil
* Pesticide/Herbicide Residue	Molds	* Protein
* Hidden/Dead Insect Infestation	Mycotoxins	* Free Fatty Acid
Protein	Pesticide/Herbicide Residue	* Chlorophyll 3/
Farinograph	Stress Cracks	* Peroxide Value 3/
Amylograph	Protein	
Mycotoxins	Age	
Extensigraph	Fiber 2/	
Ash	Carbohydrates 2/	
Alpha-amylase	Oil 2/	
Bake Test		
Hardness		
1,000 Kernel Weight		
Mixograph		

1/ Asterisk criteria were recommended by 20 percent or more of the end-users. Other criteria were below 20 percent.
2/ Tested by foreign corn users but not wanted as additional tests.
3/ Requested by foreign soybean processors but not routinely tested.

Expanding the standards to include additional quality criteria as listed in table 2 can be accomplished in three ways: (1) establish limits and have the criteria affect the grade designation, such as the percent of foreign material; (2) establish no limits and report the criteria on each official grade certificate, such as the percent of moisture; or (3) establish no limits and provide the testing service only upon request, such as the percent of protein in wheat.

The following is a discussion on the feasibility of testing for the quality criteria astericked in table 2 as part of the Official U.S. Standards for Grain.

1. Falling Number. The national inspection system currently provides falling number testing service in the Spring wheat market. This service is available upon request as a separate inspection service. The falling number test measures the affect of alpha-amylase on wheat. Expanding the falling number testing program to include all wheat and be reported on all certificates, such as moisture, would represent a substantial cost to the national inspection program. It is estimated that such a program would cost between 2 and 2.5 million dollars.

If the marketplace recognizes the usefulness and related product value of the falling number results, as indicated by the millers surveyed, then expanding the testing program may be warranted. It is unlikely, however, that the marketplace will support measuring all wheat for alpha-amylase activity (the result of sprouting). Offering the service upon request may be a more reasonable approach.

FGIS and ARS are investigating an alternate testing technique which provides information similar to the falling number test. The Rapid Visco-Analyzer is a newly developed testing procedure for estimating alph-amylase activity through the use of a "stirring number" measurement. Additional work is required to refine the testing process and to relate "stirring number" to actual alpha-amylase activity. The Rapid Visco-Analyzer has the potential for being a rapid, accurate screening test suitable for field applications. In addition to investigating the alternate testing procedure, research continues to develop a testing method to actually measure alpha-amylase activity.

2. Pesticide/Herbicide Residue. FGIS is researching pesticide/herbicide residue testing for grain. Reliable and accurate screening techniques do not exist at this time for field applications. FGIS and ARS will continue research to develop an accurate, reliable screening method.

Existing testing methods involve gas chromatography/mass spectroscopy (GC/MS) detection and high pressure liquid chromatography (HPLC) equipment which is not conducive to the inspection system. The equipment costs alone exceed $100,000 per laboratory. Additional factors to consider include testing volume, labor costs, and the different agricultural chemicals used on or around grain.

3. Hidden/Dead Insect Infestation. ARS and FGIS are cooperating on two research projects concerning the detection of internal infestation in wheat. This program's goal is the quantitative determination of hidden insect infestation by image analysis of x-ray photographs. The project is underway at the USDA/ARS laboratory in Albany, California. Although 40 percent of the U.S. millers and processors in 1981 used x-ray as a quality control factor for accepting grain shipments, problems with the quantitative identification of the actual insect or larvae stage kept the process from widespread industry acceptance.

The other study is on biochemical detection and identification of insects and insect parts in whole and milled grain. This technique utilizes insect myosin to produce polyclonal antibodies in rabbits. These antibodies are used to develop an immunosorbent assay (ELISA) for myosin. Preliminary results indicated the technique can detect myosin in all major grains pests.

Presently, the ELISA technique is still being researched. However, both Kodak and Biorad have shown interest in developing an ELISA test kit for use by the milling and baking industry for quantifying the amount of insect fragments in commodities to meet insect contamination tolerances established by the Food and Drug Administration.

In addition to the ELISA immunosorbent assay which could be used to identify insect fragments present in the sievings of whole grains, another technique is available for removing dead insects and dockage from wheat. The Kice Aspirator and the South Dakota Seedblower are commercially available instruments which remove dead insects from grain with air currents. These two instruments have been researched by the Millers National Federation (MNF) for removing dead insects from wheat and the data show that the technique is highly successful. In 1988, MNF plans to install the Kice Mini-Aspirator at a number of mills for use in removing dead insects and dockage from wheat.

4. Soybean Oil and Protein. FGIS is field testing NIR calibrations for soybean oil and protein. Based on the outcome of the field test, official soybean oil and protein testing under the United States Grain Standards Act could be available by the fall of 1989. FGIS will rely on the Soxtec extractor as a reference method for oil. The Kjeldahl procedure will be used as the reference method for protein.

FGIS does not plan to include soybean oil and protein as grading factors. These factors will be considered as official criteria and reported as information on the certificate.

We estimate the cost for official agencies currently grading soybeans to equip their laboratories would be approximately $1,750,000. The initial equipment cost for FGIS laboratories is estimated to be approximately $616,000. Equipment for FGIS' quality control program and initial training costs will be approximately $150,000. Annual costs for administering the quality control program is estimated to be $125,000. The total cost of implementation would be $1,750,000 for official agencies and $891,000 for FGIS.

5. Free Fatty Acid. High levels of free fatty acid (FFA) in soybean oil result in refining losses and increased costs due to the necessity of removing FFA from the oil. The National Soybean Processing Association and the Federation of Oils, Seeds, and Fats Association have a trading rule of 0.75 percent maximum FFA for crude degummed soybean oil.

FFA is commonly tested by industry through a chemical titration procedure. This procedure extracts the oil from the soybean then a titration is performed. The procedure is accurate but too untimely to fulfill the wide ranging needs of the national inspection program. The analysis takes approximately 6 hours to complete.

FGIS is researching the possible use of NIR technology to determine FFA levels in soybeans. The problem thus far with NIR determinations for FFA in soybeans is the testing error associated with the analysis. When testing samples for FFA levels at or near 0.75 percent, the testing error is approximately 0.68 percent. FGIS does not consider tests to be accurate or reliable when testing error approaches the constituent level analyzed. FGIS continues research into NIR testing procedures to determine if the error can be reduced to a more acceptable level.

FGIS revised the soybean mold damage interpretation to approximate the maximum FFA training rule. Studies indicate the damage interpretation correlates closely with the maximum FFA level.

6. Soybean Chlorophyll. Soybean chlorophyll may be addressed under the general category of soybean oil color. A darker crude oil color (red) indicates a level of damage to the seed and color fixation in oil makes it difficult for the oil processor to meet finished oil color requirements. Green (chlorophyll) color due to immature or damaged beans is detrimental to oil quality as it is also difficult to remove.

Oil color determinations may be made by using either an objective testing procedure or a subjective testing procedure. According to the Assessment of Oilseed Oil Quality Factors report dated May 18, 1987, from the ARS, Northern Regional Research Center, it is possible to objectively determine oil color with an official method using 1.5 grams of clean, filtered oil; spectrograde-hexane as dilutant; and a spectrophotometer costing about $5,000.

Visual (Lovibond) procedures require 25-50 ml of filtered oil, a viewer, and standard color plates. A spectrophotometer is not required for this test; therefore, the test relies on a subjective determination made by the laboratory technician analyzing the samples. The technician must compare the color of the oil to the standard color plates to make a final determination.

It is necessary to extract a small amount of oil (or possibly expel it under pressure) to obtain a sample for color determination under these testing procedures. Extraction requires the use of flammables, fume hoods, a cold water source with drain, and trained lab technicians. Many facilities, e.g., elevators and office buildings, would not permit installation of such equipment. Safety is a major consideration. Expelling oil may be worth examination; however, the representativeness of oil obtained by this method needs investigation and obtaining a sufficient quantity by this method may be difficult. ARS and FGIS will continue to research testing methodology to develop an appropriate testing procedure for field application.

7. Soybean Peroxide Value. Peroxide values are a measure of the oxidative state of an oil, as stated in the Assessment of Oilseed Oil Quality Factors report from the ARS, Northern Regional Research Center, dated May 15, 1987. This report recommends a formula for total oxidative state (totox) as more definitive of the degree of oil oxidation. This formula (2 X Peroxide Value + Anisidine Value) indicates the degree of oil deterioration due to the action of lipoxygenase on polyunsaturated fatty acids of the oil. These ". . . products of oxidation present in crude oils are thought to have a negative impact on the flavor and stability of finished oils." High quality soy oils generally have a totox value of less than 3.0. The totox value is obtained by measuring the Hexanal content of the full fat meal. This is done with a headspace analyzer.

The determination of peroxide value alone is a wet chemistry procedure involving the titration of a 5.0-gram oil sample dissolved in a mixture of glacial acetic acid and chloroform. This is not a procedure adaptable to routine use in the inspection system.

G. GLOSSARY OF TERMS

ALVEOGRAPH - The alveograph measures the resistance of dough to extension and the extent to which it can be stretched. A sheet of dough of definite thickness prepared under specified conditions is expanded by air pressure into a bubble until it is ruptured, and internal pressure in the bubble is graphically recorded.

AMYLOGRAPH - The amylograph is a recording viscometer that may be used primarily to detect the effect of alpha-amylase enzyme on flour viscosity as a function of temperature. The high viscosity of the starch gel is counteracted by action of alpha-amylase, which liquefies starch granules during the heating of the slurry. The amylograph value provides information on probable effect of alpha-amylase during the baking process.

ASH - Ash content of wheat is related to the amount of bran in the wheat and hence has rough inverse relationships to flour yield. Small or shriveled kernels usually have more bran on a percentage basis and therefore more ash, and yield less flour than large plump kernels.

BAKING TEST - An end-performance test of a flour product. Test baking is used not only in the final evaluation of the flour's performance in a specific baking process, but also to evaluate different treatments or manufacturing processes according to their effect on performance.

BREAKAGE SUSCEPTIBILITY - The breakage susceptibility test detects the potential for kernel fragmentation or breakage of a load or batch of corn subjected to impact forces when transported mechanically. Breakage susceptibility is closely correlated with the degree of stress cracks in the endosperm.

EXTENSIGRAPH - The extensigraph records a load-extension curve for a test piece of dough stretched until it breaks. Characteristics of load-extension curves or extensigrams are used to assess general quality of flour and its response to improving agents.

FALLING NUMBER - This test method is based on the unique ability of the alpha-amylase enzyme to liquefy a starch gel. Strength of the enzyme is measured by falling number, defined as the time in seconds required to stir and allow the stirrer to fall a measured distance through a hot aqueous gel undergoing liquefaction.

FARINOGRAPH - The farinograph measures and records resistance of a dough to mixing. It is used to evaluate absorption of flours and to detect stability and other characteristics of doughs during mixing.

FATTY ACID COMPOSITION - Methyl esters of fatty acids are separated and detected quantitatively by gas chromatography.

FREE FATTY ACID - A measure of the uncombined fatty acids in a fat.

KERNEL SIZE - Kernel size is closely related to kernel weight and would be expected to be a factor affecting flour yield.

MIXOGRAPH - The mixograph measures and records the resistance of a dough to mixing. The mixing curve indicates optimum development time, stability, and other characteristics of doughs.

PEROXIDE VALUE - A measure of the degree of oxidative rancidity of a fat.

SEDIMENTATION - The sedimentation test is a method for estimating the gluten "strength" of wheat.

THOUSAND KERNEL WEIGHT - A measure of average kernel size. The larger the kernel size, the greater should be the ratio of endosperm to bran.

List of Abbreviations

1. United States Standards:

Broken corn and foreign material	BCFM	Moisture	M
Class	CL	Odor	ODOR
Club wheat	CLUB	Sample grade	SG
Contrasting class	CCL	Sample grade factors	SGF
Damaged kernels (total)	DKT	Shrunken & broken kernels	SHBN
Dockage	DKG	Split soybeans	SPL
Foreign material	FM	Subclass	SCL
Garlicky	GAR	Test weight per bushel	TW
Heating	HTG	Total defects	TD
Heat-damaged kernels	HT	Vitreous kernels	VIT
Infestation	INF	Waxy kernels	WAXY
		Wheat of other classes	WOCL

2. Criteria not found in United States Standards:

Artificial drying temperature	ADT	Hardness	HRD
Age	AGE	Insects (hidden/dead)	IHD
Alpha-amylase	ALA	Kernel size	KS
Alveograph	ALVE	1,000 kernel weight	KW
Amylograph	AMYLO	Metabilized energy	ME
Bacteriological profile	BP	Mixograph	MIX
Breakage susceptibility	BS	Mold	MLD
Baking test	BT	Oil	OIL
Carbohydrates	CARB	Pesticide/herbicide residue	PHR
Chlorophyll content	CHL	Pesticide residue	PR
Color	COL	Protein	PRO
Extensigraph	EXT	Peroxide value	PV
Fatty acid composition	FAC	Radiation	RAD
Farinograph	FAR	Starch	S
Free-fatty acid	FFA	Stress cracks	SC
Fiber	FIB	Sedimentation	SED
Falling number	FN	Variety	V
		Wet dry gluten	W/DG

Summary of Countries Surveyed

Country	Percent of U.S. Export 1/			Survey Responses		
	Wheat	Corn	Soybeans	Wheat	Corn 2/	Soybeans
Belgium	0.6	1.6	4.2			1
Brazil	0.3	1.2	2.1	4		
Chile	0.1	0.4	0.0	1		
China	6.3	3.2	2.0	1		1
Colombia	0.9	0.0	0.9			1
Egypt	8.0	3.8	0.3	2		
England	0.0	0.2	1.6	1		
France	0.0	0.0	2.3	1		
Germany	0.0	0.1	6.6			1
India	0.0	0.0	0.0	3		
Indonesia	0.7	0.3	0.7	4		
Italy	1.2	0.3	1.9	1		
Japan	10.0	31.6	18.2	6		
Korea	6.0	10.9	5.2	4		3
Netherlands	0.1	0.6	17.8	3		
Norway	0.0	0.0	1.0	1		
Philippines	2.8	0.0	0.0	5		
Portugal	0.4	1.7	2.7			1
Spain	0.0	1.5	8.3			1
Switzerland	0.0	0.0	0.0	1		
Taiwan	2.7	7.4	8.9	6		1
Venezuela	1.8	0.0	1.1	3		
Yugoslavia	1.4	0.7	0.6	—	—	—
			Totals	47	31	11

1/ 1987 average.
2/ Thirty-one responses received. Countries unknown.

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